

Using Natural Cementation Systems to Control Corrosive Dust on Un-surfaced Roads

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Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE FEB 2010		2. REPORT TYPE		3. DATES COVERED 00-00-2010 to 00-00-2010	
4. TITLE AND SUBTITLE Using Natural Cementation Systems to Control Corrosion Dust on Un-surfaced Roads				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US Army Engineer Research and Development Center,CERL,3909 Halls Ferry Rd,Vicksburg,MS,39180				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES 2010 U.S. Army Corrosion Summit, Huntsville, AL, 9-11 Feb					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 20	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Army Training Areas Can Be Subject to Problems of Dust

- **Unsurfaced roads and unsurfaced landing zones are major problems in arid terrain**
- **Dust introduces abrasives into the vehicle systems and clogs air filters**
- **Dust control agents are frequently inorganic salts, chlorides that can produce additional corrosion problems**
- **Conventional paving is not practical**



Alkali-based Silicate Cements—An Alternate Solution



Soil solidified with alkali-activated glass slag

- **Alkali-based silicate (ABS) cements are special cements formed by mixing a concentrated alkali solution with a finely ground reactive silicate or aluminum silicate**
- **ABS cements are strong, fast-setting, inexpensive to make and very versatile**
- **Manufactured from glassy silicates (typically metallurgical slags), volcanic glass, fly ash and low-fired clays**
- **Can use waste alkali from manufacturing operations**
- **No Portland cement is involved**



Pohakuloa Training Area (PTA) as a Test Site

- **Serious dust problem at site**
- **Soil is abrasive, corrosive dust**
- **Soil is largely volcanic glass and should be reactive**
- **Cementation should be more durable than any type of dust palliative**



**Typical stretch of Access
Road at PTA**



PTA Access Road



Suitability of PTA Site

- **Serious dust problem**
- **Little relief**
- **No drainage problems**
- **Moderate traffic**
- **Access available for alkali-activation treatment**

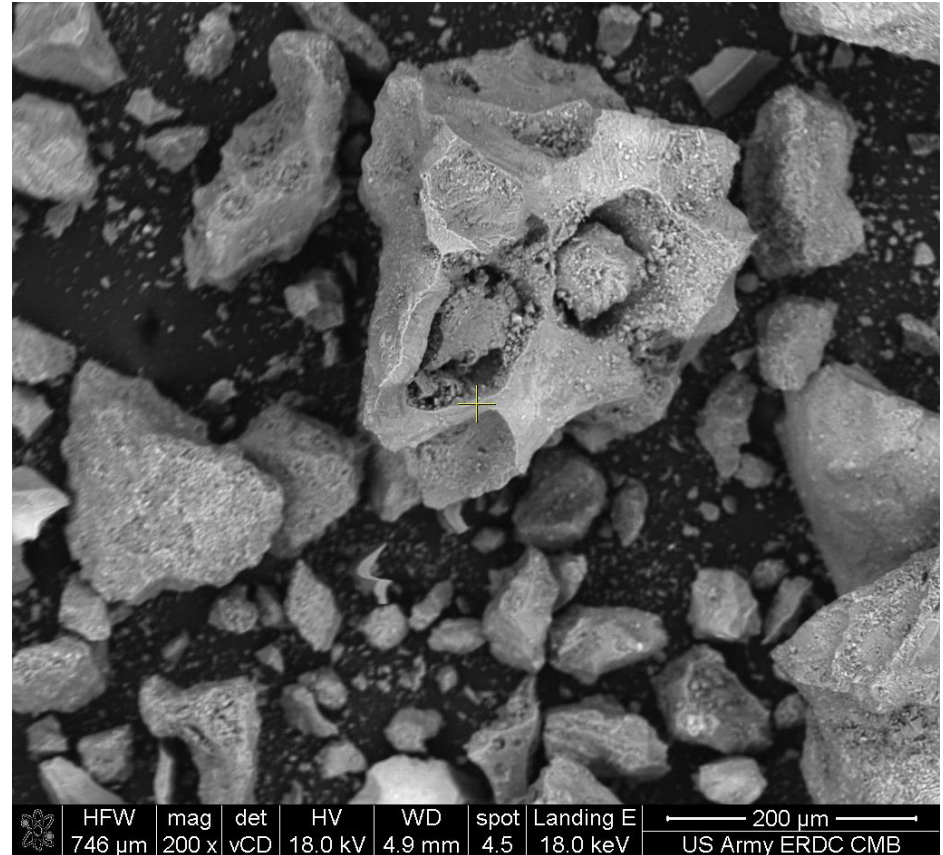


PTA Access Road



Untreated Soil—Weathered Lava Glass

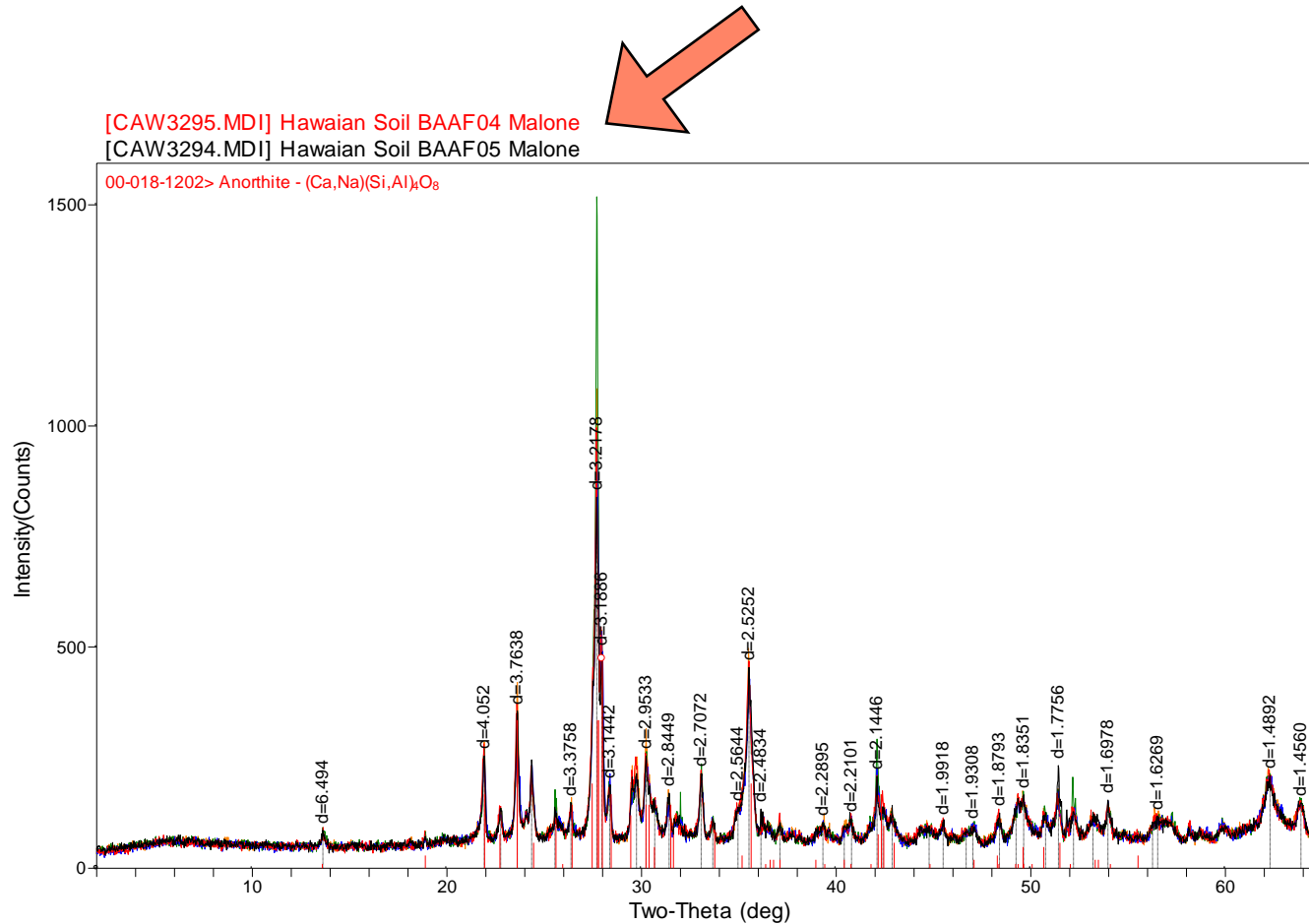
- Mostly glassy, easily reacted with alkali
- Very little crystalline material
- Sharp edges, and corners
- Wide range of grain sizes



Photomicrograph of Soil



X-Ray Diffraction Pattern for PTA Soils

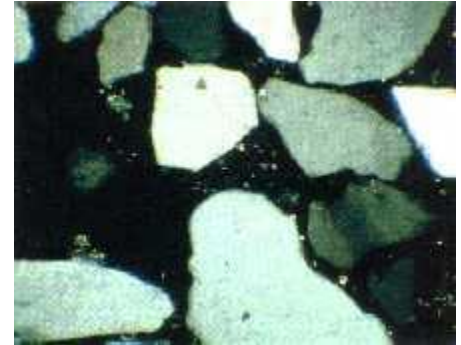


Single
crystalline
phase
present– the
feldspar
Anorthite

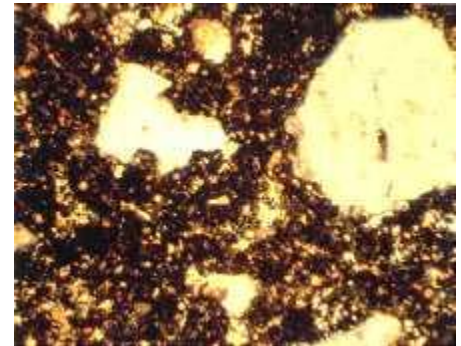


How is Alkali-activated Glass Different from Conventional Cement?

- Glass can be both the aggregate and form the cementing phase
- Waste glass (slag, fly ash) can be used
- More alkaline solution is used to form the bonding gel and other phases
- Strength can be comparable to Portland cement mortar



Alkali- activation of glass



Conventional cementation

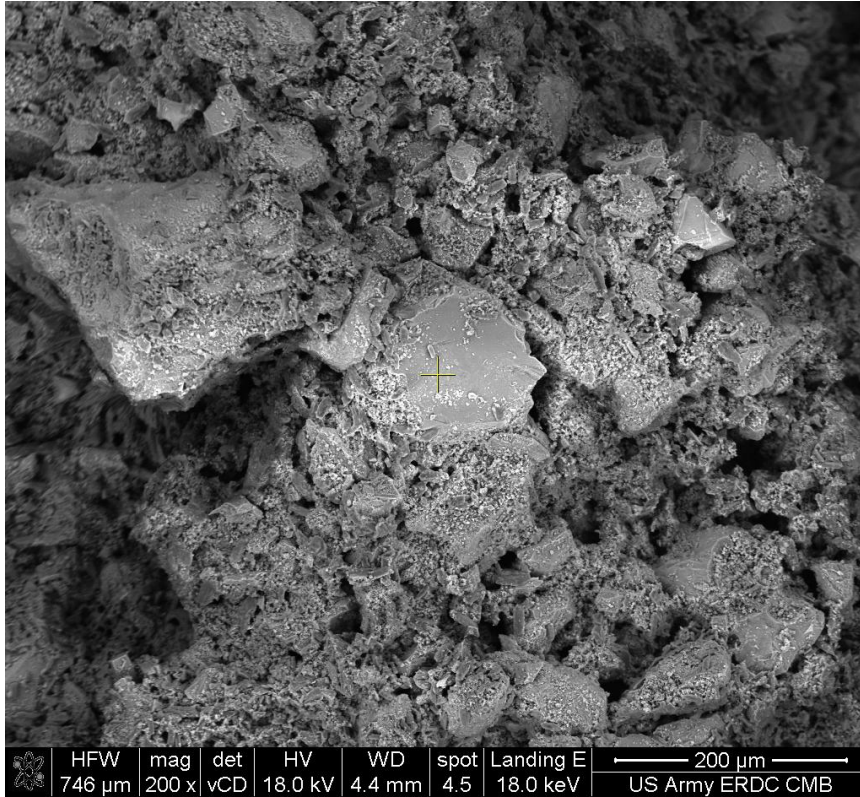


Why Use Alkali-treatment?

- **Fast:** Mixture sets in hours and gets ultimate strength in days
- **Easy to Obtain Materials:** Suitable raw materials are available almost everywhere (fly ash, slag, calcined clays)
- **Economical:** Uses waste materials or low-fired clay soils
- **Versatile:** Basic chemistry adapts from a wide variety of glassy materials – even volcanic glass
- **Variation of natural weathering process that occurs in volcanic ash deposits**



Initial Treatment with Alkali



PTA soil after alkali treatment

- Alkali attacks edges and corners of coarse grained materials
- Fines can react completely
- Silica gel that forms has form similar to CSH phase
- Secondary minerals (zeolites) contribute to cementation



Alkali-activation Treatment of Unpaved Roads

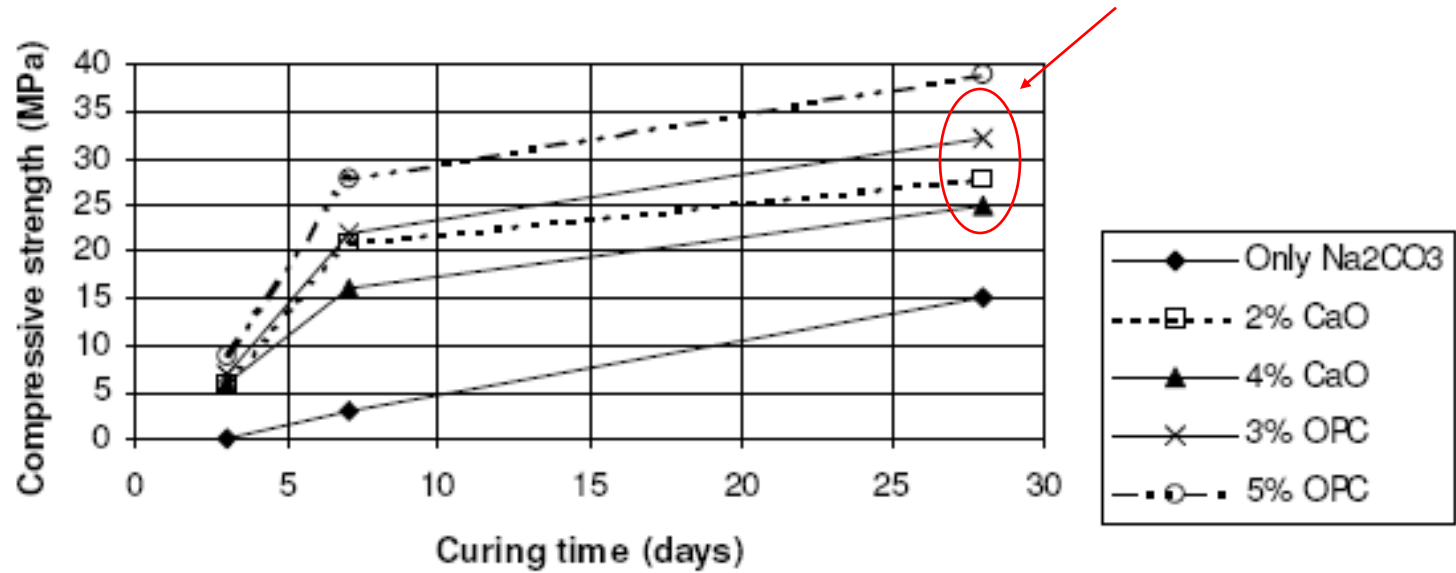
- **Widely used in Australia**
- **Marketed by Blue Circle Cement Company**
- **Reported to use Na-rich kiln dust**
- **Broad range of compositions**



Roadment® application



Comparison of Alkali-activation and PC addition



*Compressive strength vs. Curing time for different mineral activators
(with 6% Na_2CO_3 in binder)*

Can we do better with glassy PTA soil?



Initial Mix Development

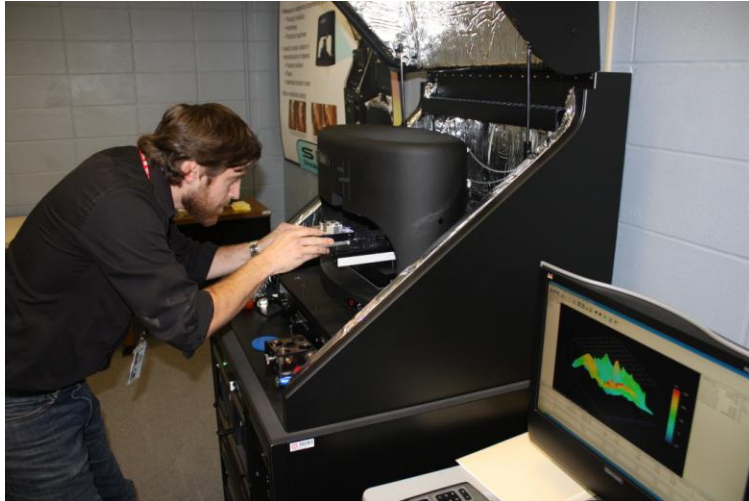
- First trials have produced moderate early strengths
- 28-day strength should be comparable to or better than published results
- Work is continuing using local fly-ash as secondary silica source
- No significant technical barriers have been encountered



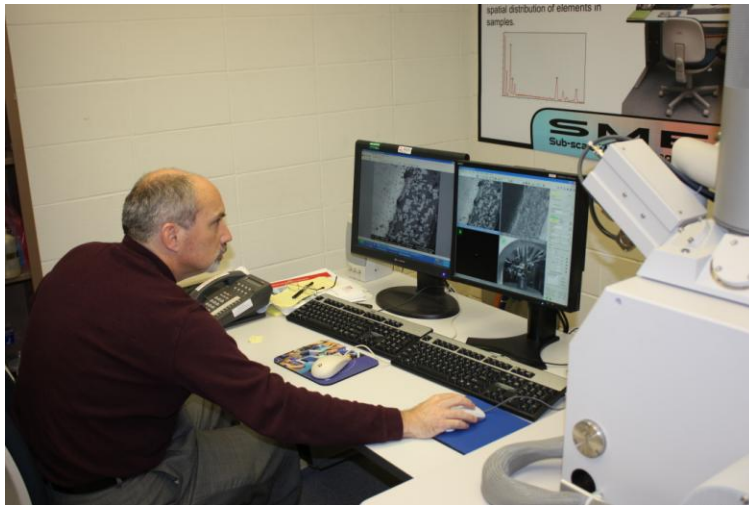
Test cylinder with sodium carbonate activation



Future Work



- **Structure-Property Characterization**
 - Compressive strength
 - Nanoindentation
 - Modulus and hardness of transition zones
 - SEM with WDS
 - Chemical analysis
 - Fracture surface characterization
- **PTA road stabilization**
 - Transition from laboratory to field



SUMMARY

- **Control of abrasive dust is a serious corrosion and equipment maintenance issue**
- **Alkali-activated cementation has been used for glassy materials containing glassy silicates**
- **Reports in the literature indicate it should work on unpaved roads**
- **Experience from Australian full-scale road stabilization indicates no technical barriers**
- **Initial lab results were successful**
- **Planning for conducting and evaluating stabilization program at PTA is proceeding**



ACKNOWLEDGEMENTS

The authors wish to recognize the Sponsors of the DoD Corrosion Prevention and Control Program:

- 1. Office of Under Secretary of Defense, Office of Corrosion Policy and Oversight (Director, Mr. Dan Dunmire).**
- 2. Deputy Assistant Secretary of the Army Acquisition Policy and Logistics (Army Corrosion Control Prevention Executive, Mr. Wimpy D. Pybus).**
- 3. Assistant Chief of Staff for Installation Management (Mr. David Purcell).**
- 4. Headquarters, U.S. Army Installation Management Command (Mr. Paul Volkman).**

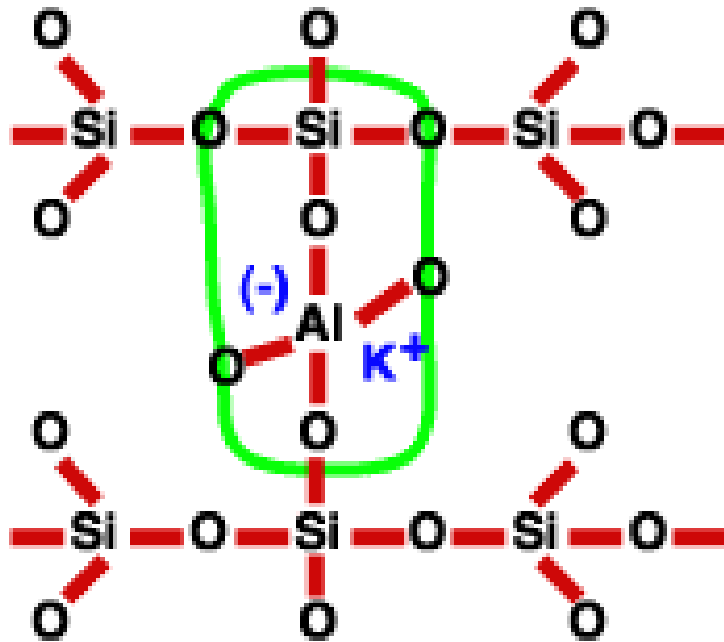
F10AR06 Accelerating Natural Cementation for Road Stabilization



Questions



Why Hasn't ABS Cement Taken Over the Market?



Si-O-Al-O-Si bond

- It is NOT Portland cement!
- No one writes specs for use of non-PC concrete
- Requires phosphate or borate retarders –products used to regulate set with PC will not necessarily work with alkali-based silicates
- Handling and placing characteristics are slightly different-- uses more vibration-- uses minimum water



Alkali-slag Patching Material

